M09-0146-Presentation

National Aeronautics and Space Administration

A Process For Technology Prioritization In A Competitive Environment

In Space Propulsion Technology Project
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Brand Griffin/Gray Research Inc.
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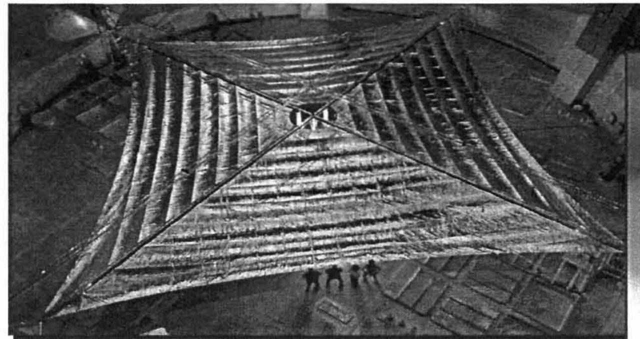
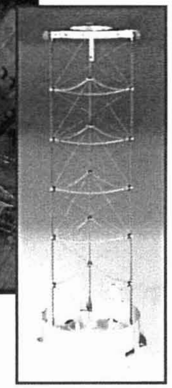
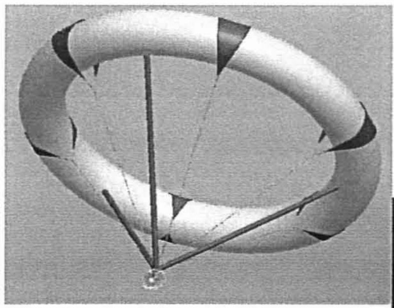
In-Space Propulsion Technology (ISPT) Project

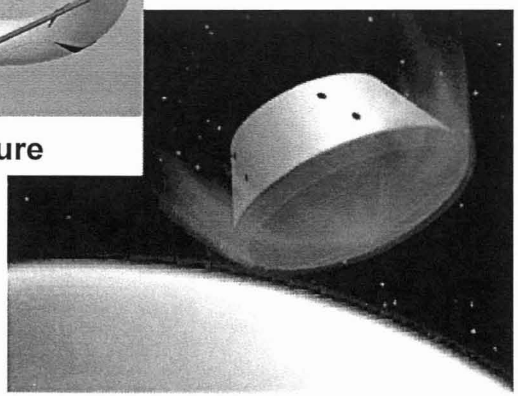
Solar Electric



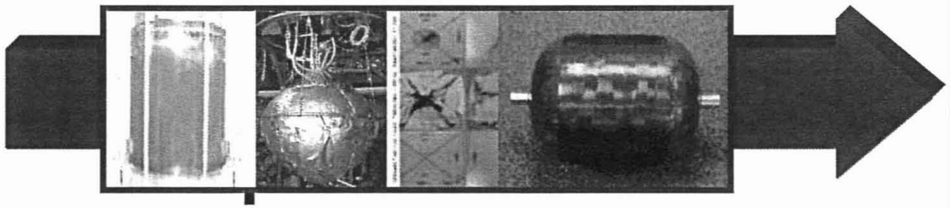


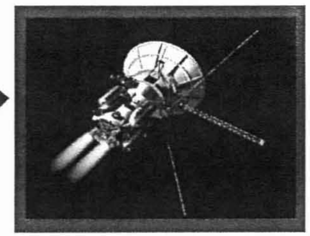
Solar Sails





Aerocapture

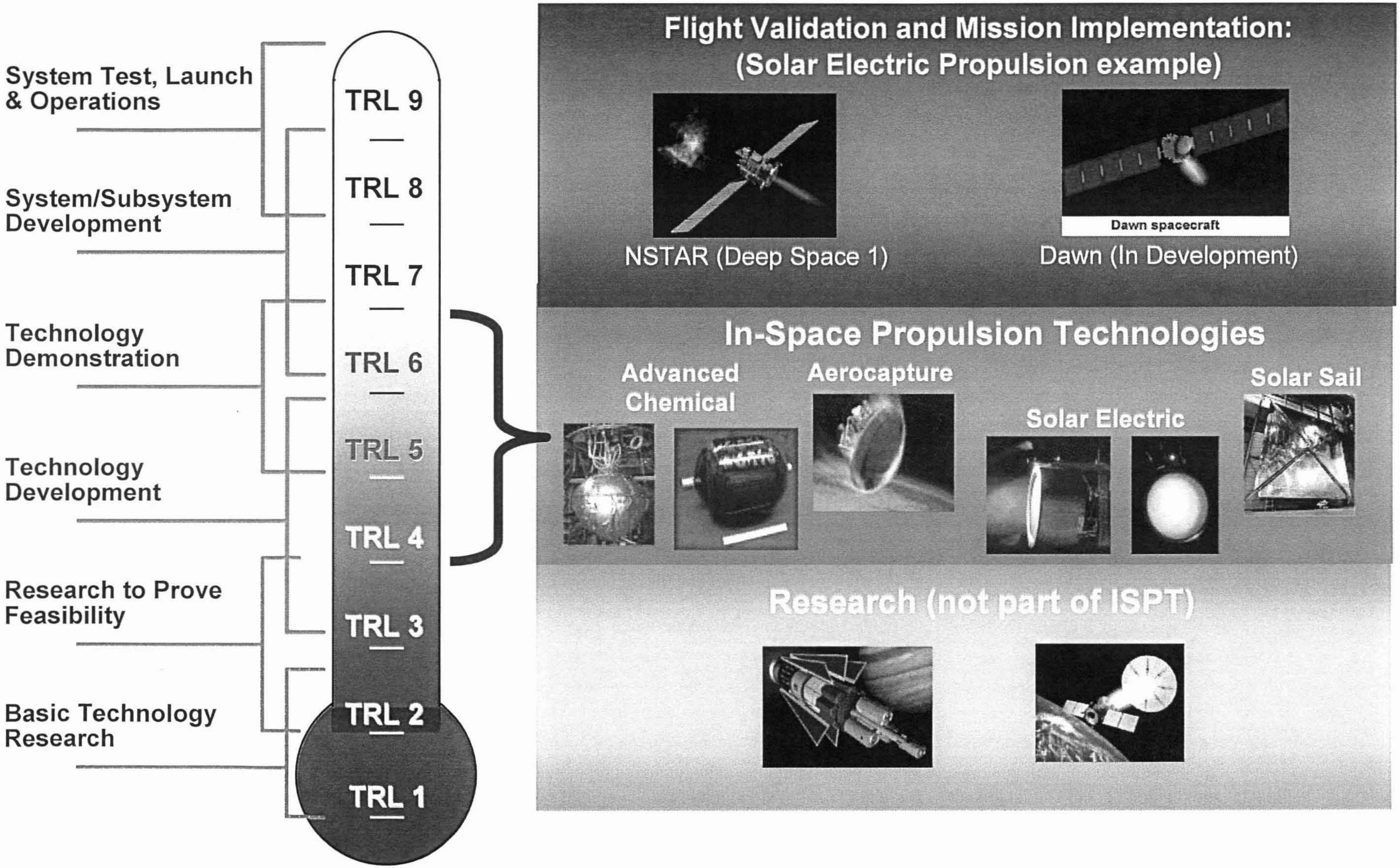




Advanced Chemical

Emerging

ISPT Focuses On Mid-TRL
Propulsion System Development and Integration



Mission Driven Technology Planning Activity

Objective:

Identify the current, most likely “need date” for each technology and create ISPT technology area development schedules based on this “mission pull”

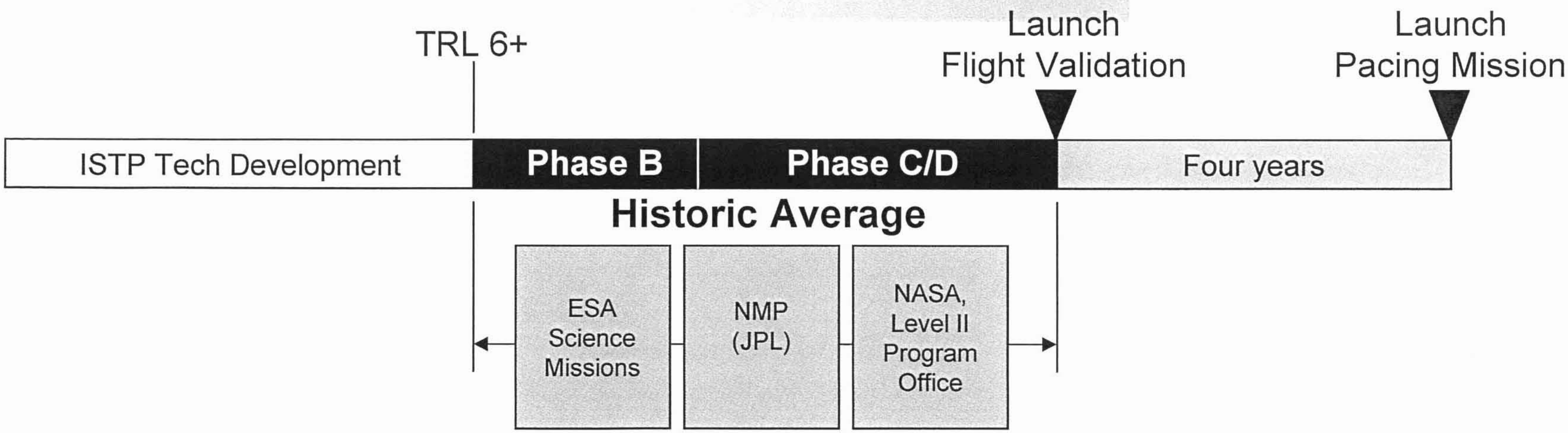
Base schedules on:

- Launch date of first flight opportunity (pacing mission)
- Historic average for spacecraft program implementation phases

Ground Rules:

- All technologies require flight validation (except NSTAR Heritage or commercial EP)
- Minimum 4 years between successful flight validation and pacing mission

Schedule Driven by Launch Date



Mission Driven Technology Planning

Why was this activity undertaken?

- Content for upcoming NASA/ISPT NRA (2006 ROSES) was needed. Technology teams needed to formulate acquisition strategy for coming years' requirements. ISPT program management needed to prioritize aquisitions.
- Early planning for POP06 was underway.
- ISPT examining agency mission priorities and ISPT technology progress relative to evolving mission needs. Planning activity would enhance future reprioritization if budget fluctuations required it
- Majority of ISPT technologies were maturing beyond the "tech push" (TRL 1-3) to "mission pull" (TRL 4-6) phase. Need for the program to orient to "1st mission" for product-focused forward progress.

ISPT needed to identify the "pacing mission" for each technology to determine optimal funding for each of the technology areas within the expected program budget.

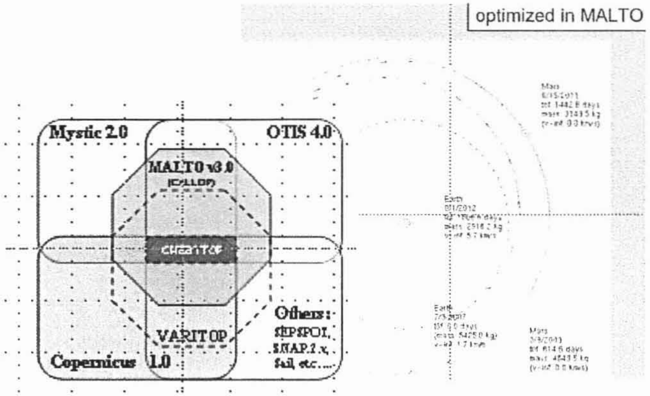
ISPT Systems Analysis Technology Area for Independent Assessment

Charter of ISPT Systems Analysis:

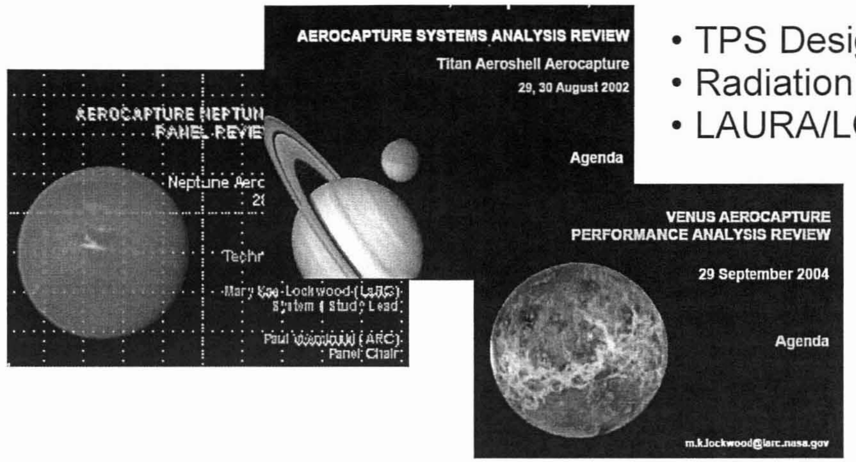
- Provide quantified inputs to ISPT Technology Project management to support investment decisions through parametric studies to show benefits of in-space propulsion technologies compared to state-of-the-art for destinations approved by the Science Mission Directorate (SMD).
- Drive out technology development challenges by conducting concept definition studies in sufficient detail to identify potential problem areas that help define and focus technology investments
- Develop systems analysis tools to promote common methods for reproducable results within each community

Systems analysis provides a non-biased assessment for critical data used in determining funding priorities and program direction.

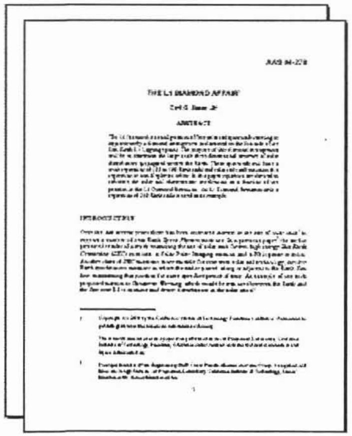
Systems Analysis
Studies, Trades & Improved Tools to Guide Investments



- Consistent LT Trajectories
- SOA algorithms/methods
- Multi-year, Inter-agency team



- TPS Design Tool
- Radiation Model
- LAURA/LORAN



- ♦ Ion & Hall Engine Performance Sensitivity Studies
- ♦ Ion Propulsion Trades for Scout, Discovery & New Frontiers Missions Generating a Reference DRM
- ♦ Standard Architecture for Gridded Ion: System Definition & Requirements
- ♦ Aerocapture Mars System Study
- ♦ Multipass Aerocapture at Multiple Destinations
- ♦ Solar Sail Heliostorm Mission Study
- ♦ Solar Sail Reqs Definition for Adv Sails & Booms
- ♦ MXER Tether Analysis, Systems Planning & Tools

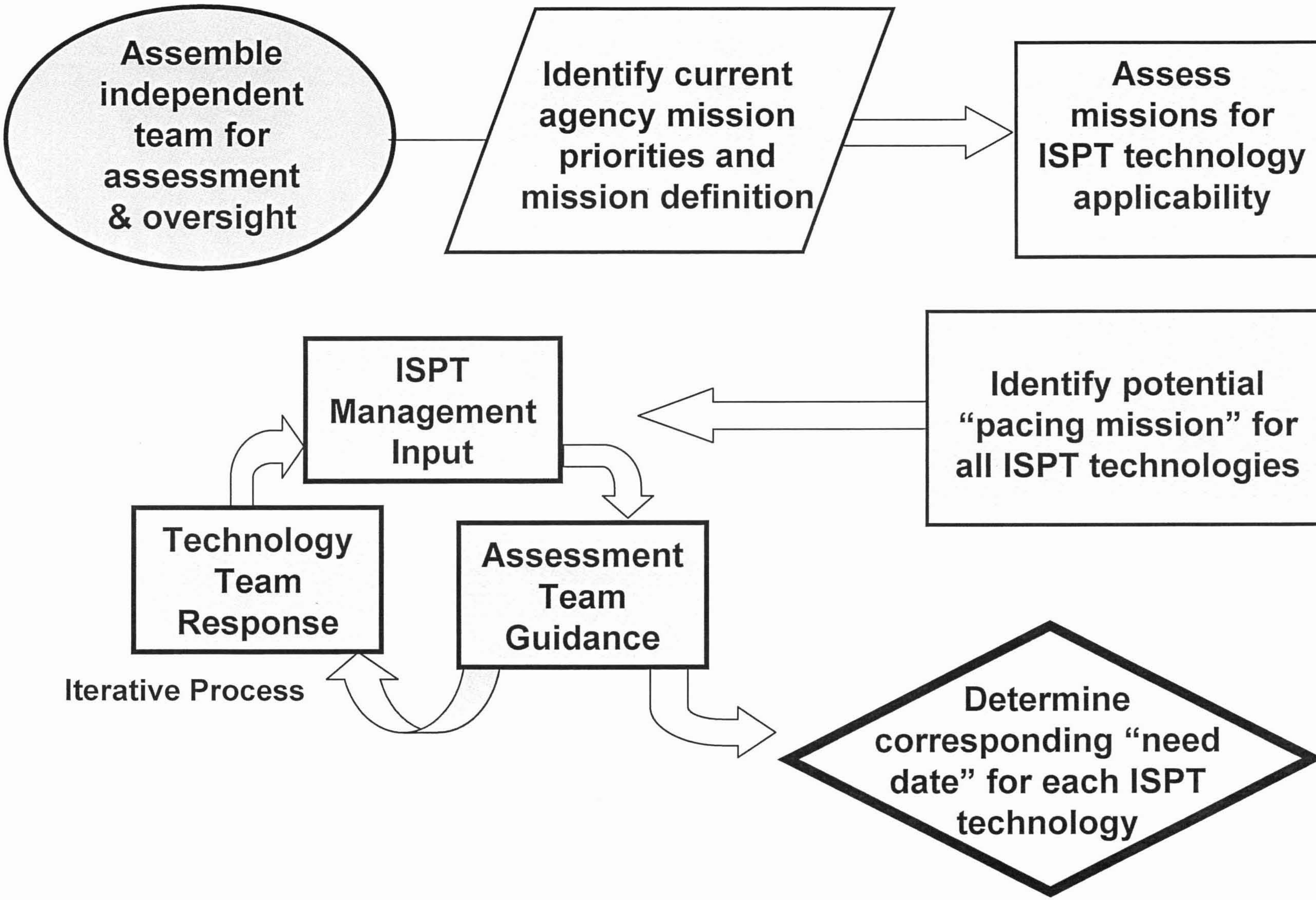
- ♦ Advanced Propellant & Engine Comparison Studies
- ♦ Advanced Chemical Propulsion System Model (ACPS)
- ♦ Aerocapture Probabilistic Risk Assessment
- ♦ Technology Infusion Studies
- ♦ Direct Trajectory Optimization Model
- ♦ Round Trip Mission Analysis Model

Central Question

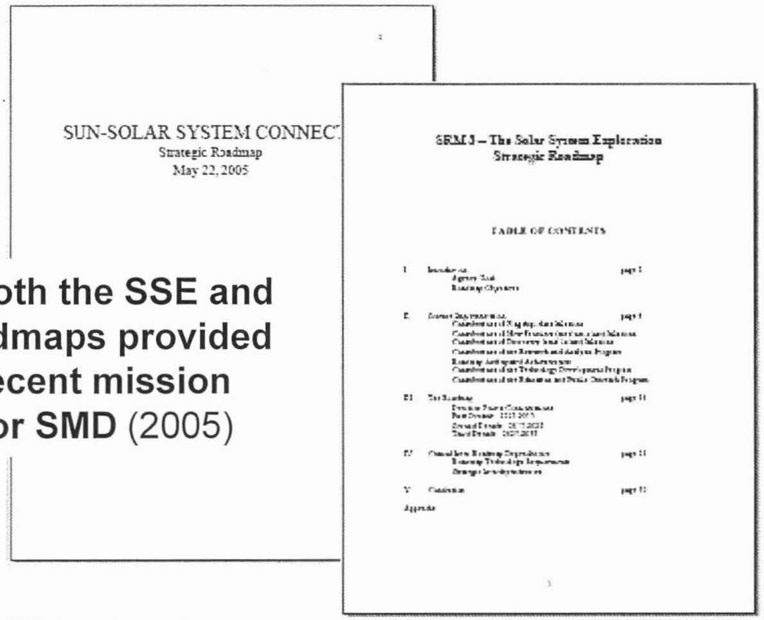
- How should funding be allocated in a product focused technology development program**?**
  - Squeaky wheel gets the grease
  - Last up at bat
  - Best track record
  - Manager's pet project
  - **None of the Above!**

- Need a priority-driven process for sequencing technology development and allocating funding.

Process for Activity

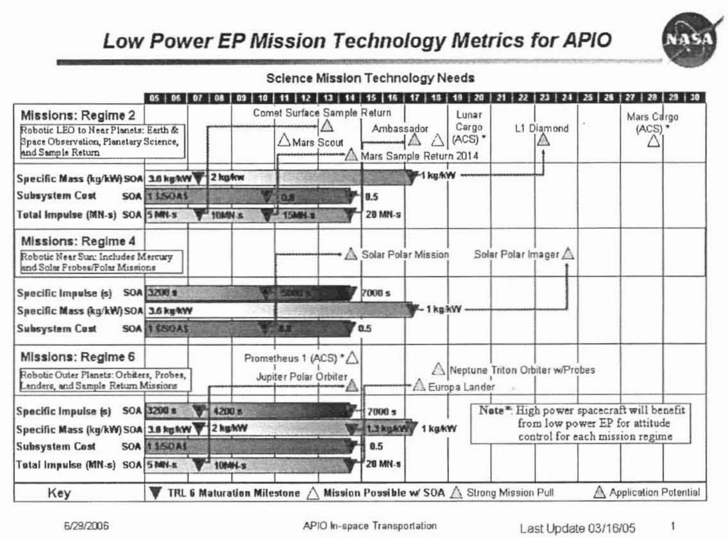


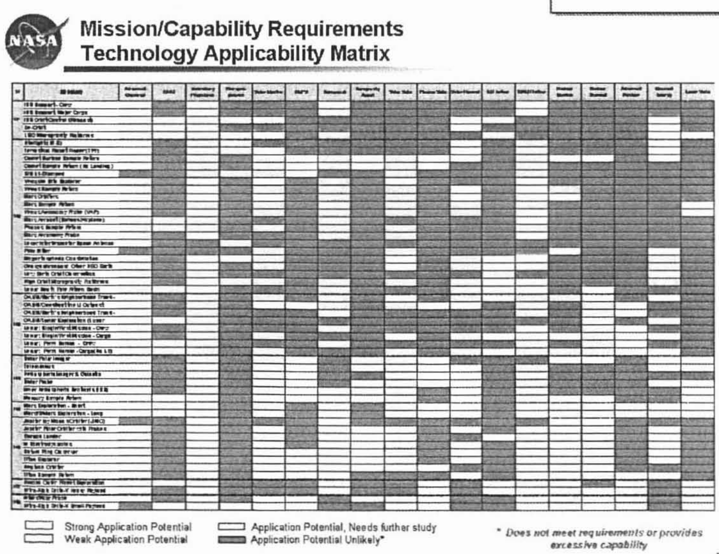
References for ISPT Technology Applicability Assessment



Drafts of both the SSE and SSSC Roadmaps provided the most recent mission priorities for SMD (2005)

CRAI/APIO effort determined most applicable missions for ISPT technologies (2004)





STEAM effort assessed ISPT technologies for 52 candidate missions (2002 & 2003)

SSE Mission Pull

				ISP Technology												
				Solar Electric			Aerocapture			Sails			Adv Chem			
Source	Class	Mission Title	Launch Date	NSTAR	NEXT	Hall	Blunt	LB	Inflat	~ 15 g	5 - 15 g	<5 g	Gels	Lox-Hydrazine	Pump Fed	Mass Reductn
SSE	NF	Pluto-Kuiper Belt Explorer	2006													
SSE	NF	Lunar South Pole Aitken Basin	2010				Earth Return									
SSE	NF	Jupiter Polar Orbiter with Probes	2010													
SSE	NF	Venus In-Situ Explorer	2013													
SSE	NF	Comet Surface (Nucleus) Sample Return (CSSR)	2013				Earth Return									
SSE	F	Europa Geophiscal Observer	2015													
SSE	F	Titan Explorer	2020													
SSE	F	Neptune System Mission	2025													
SSE	F	Comet Cryo Nucleus Sample Return	2020				Earth Return									
SSE	F	Venus Sample Return	2020													
SSE	F	Europa Astrobiology Lander	2025													
SSE	Dis-covery	Near Earth Asteroid SR	every 2 years													
SSE	Dis-covery	Comet Rendezvous	every 2 years													
SSE	Dis-covery	Vesta-Ceres Rendezvous	every 2 years													
		Venus Orbiter	every 2 years													

Applicable, studied

Likely Applicable, needs study

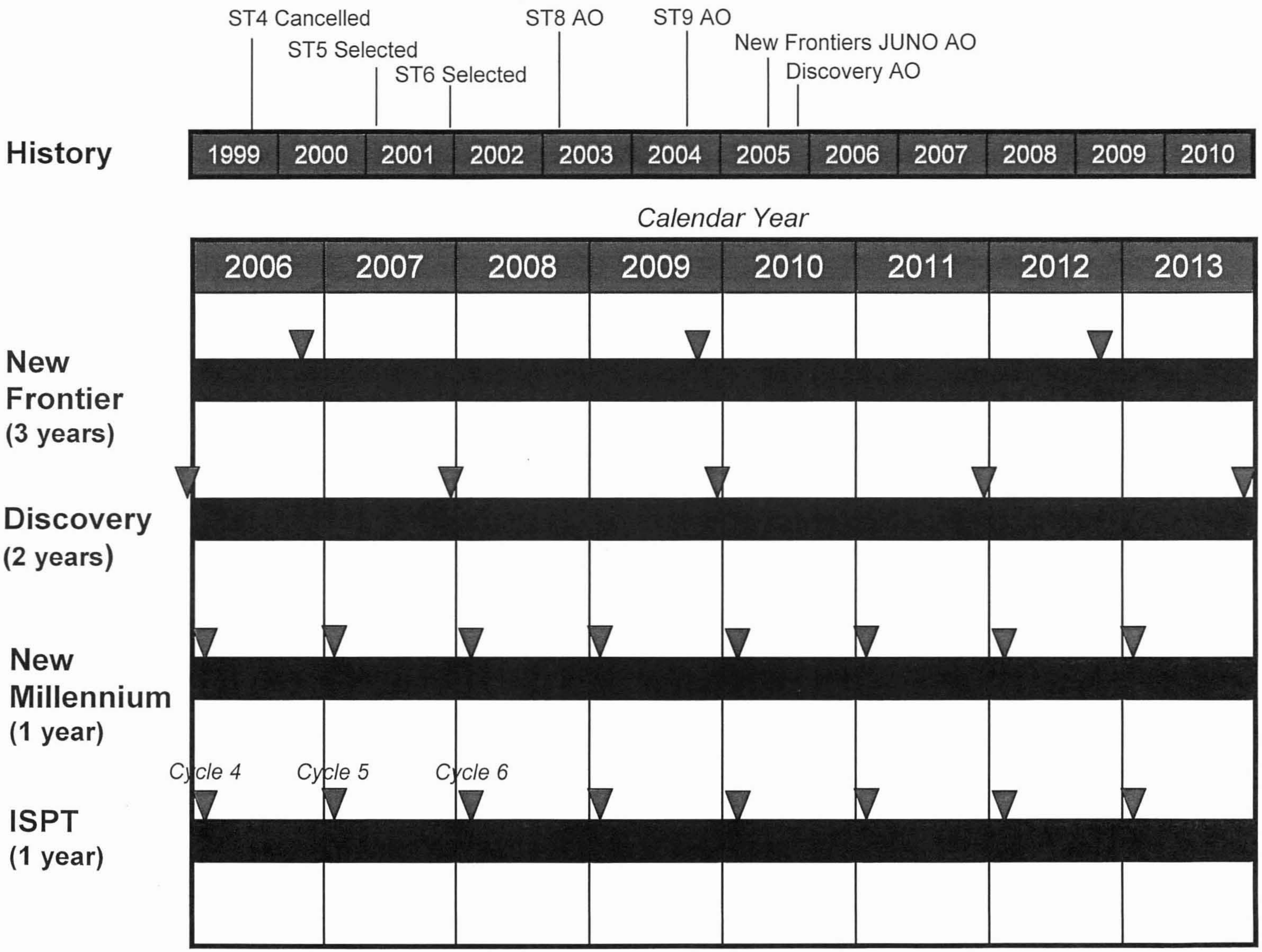
SSSC Mission Pull

				ISP Technology												
				Solar Electric			Aerocapture			Sails			Adv Chem			
Source	**Class**	**Mission Title**	**Launch Date**	NSTAR	NEXT	Hall	Blunt	LB	Inflat	~ 15 g	5 - 15 g	<5 g	Gels	Lox-Hydrazine	Pump Fed	Mass Reductn
SSSC		Magnetospheric Multi-Scale	2014													
SSSC		Heliostorm	2016													
SSSC		L1 Solar-Climate Explorer (L1SCE)	2016													
SSSC		Geospace Electrodynamic Connections (GEC)	2017													
SSSC		Inner Heliosphere Sentinels (IHS)	2017													
SSSC		L1-Earth-Sun	2018													
SSSC		L1-Missions	2018													
SSSC		Solar Orbiter (Phase 2??)	2018													
SSSC		Solar Probe	2020													
SSSC		DOPPLER	2020													
SSSC		Aeronomy and Dynamics at Mars (ADAM)	2022													
SSSC		Solar Polar Imager	2024													
SSSC		Inner Magnetospheric Constellation (IMC)	2025													
SSSC		Interstellar Probe	2025													
SSSC		Io Electrodynamics	2025													
SSSC		JPO	2025													
SSSC		Mars Atmospheric Reconnaisance Survey (MARS)	2027													
SSSC		MTRAP	2033													
SSSC		Reconnection and Microscale (RAM)	2033													
SSSC		Solar Connection Observatory … (SCOPE)	2035													

Applicable, studied

Likely Applicable, needs study

Likely Announcement Opportunities



NASA Development/Procurement

Hardware and Software for entire spacecraft

Pre Phase A

MISSION FEASIBILITY
- Goals and Objectives
- Concept/Design Evaluation Criteria
- Mission Concepts
- Life Cycle Cost Estimates
- Feasibility Assessment

Phase A

MISSION DEFINITION
- Mission Need Statement
- Functional Mission Concept
- Science Requirements
- Trade and Analysis Results
- Technology Development Plan

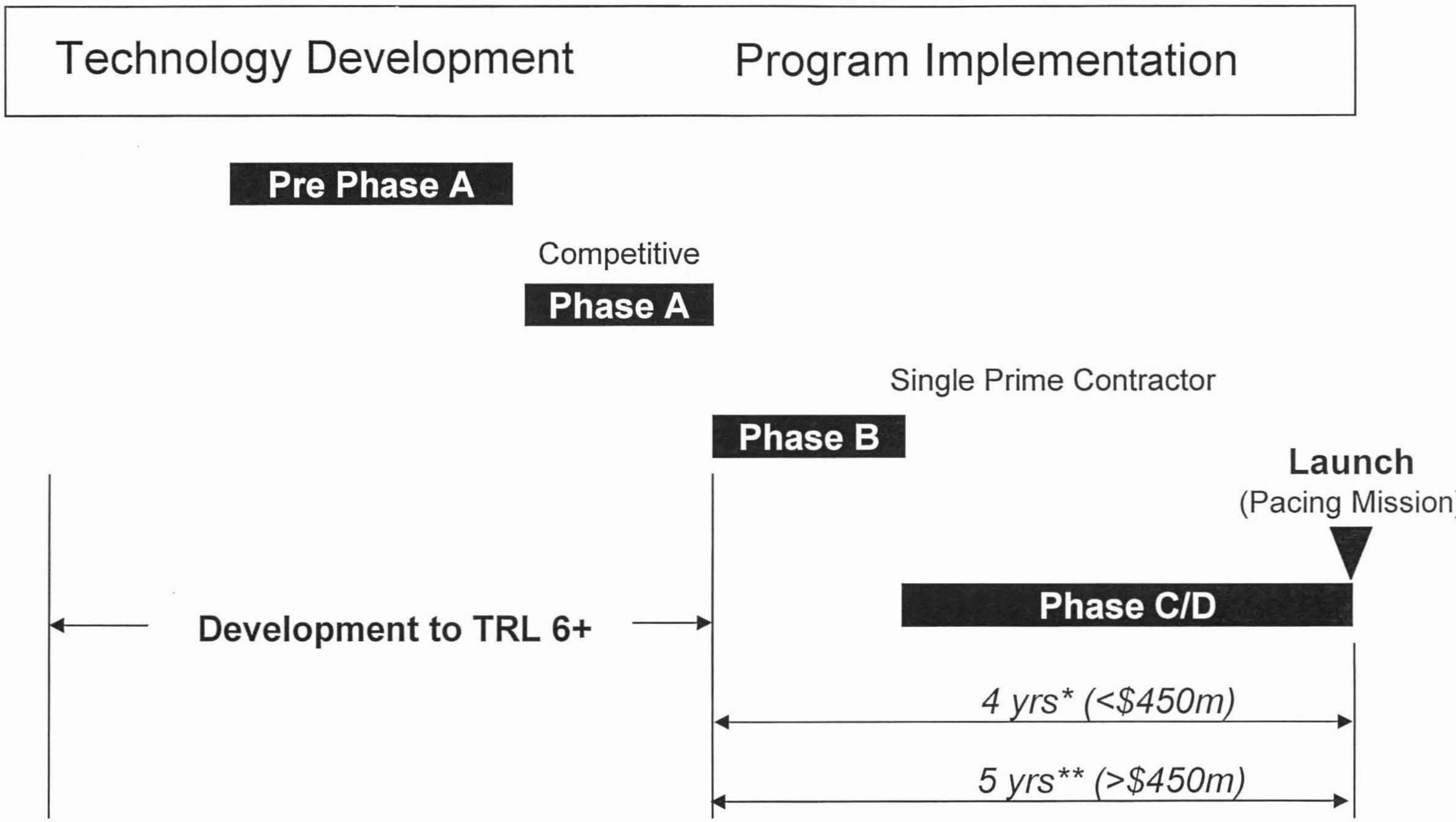
Phase B

SYSTEM DEFINITION/PRELIM DESIGN
- Systems Engineering Mgt Plan
- Risk Mgt Plan
- Configuration Mgt
- Science Payloads
- Verification Requirements
- Concept of Operations
- Trades and Analysis

Phase C/D

DESIGN DEVELOPMENT
- Lower level Design Specs
- Refine Requirements Doc
- Refine Verification Doc
- Interface Doc
- Mfg Plan
- End-to-end systems design
- Integrated Logistics Support
- Fabrication
- Integration
- Verification
- System Qualification
- System Acceptance
- Operations manuals
- Maintenance manuals

Schedule Logic



** Average of available data for NASA & ESA missions

Pacing Mission Selection

Similar Development Paths with flight validation and major mission pull

Solar Sail Propulsion

- Flight validation required
- 2016 Heliostorm is pacing mission (optimistic schedule)

Aerocapture Technology

- Flight validation required
- 2020 Titan Explorer is pacing mission for blunt body
- 2025 Neptune System Mission is pacing mission for lifting body

Technologies will be used as soon as developed

Plan to Announcement of Opportunity (Discovery Class ~ every 2 yrs.)

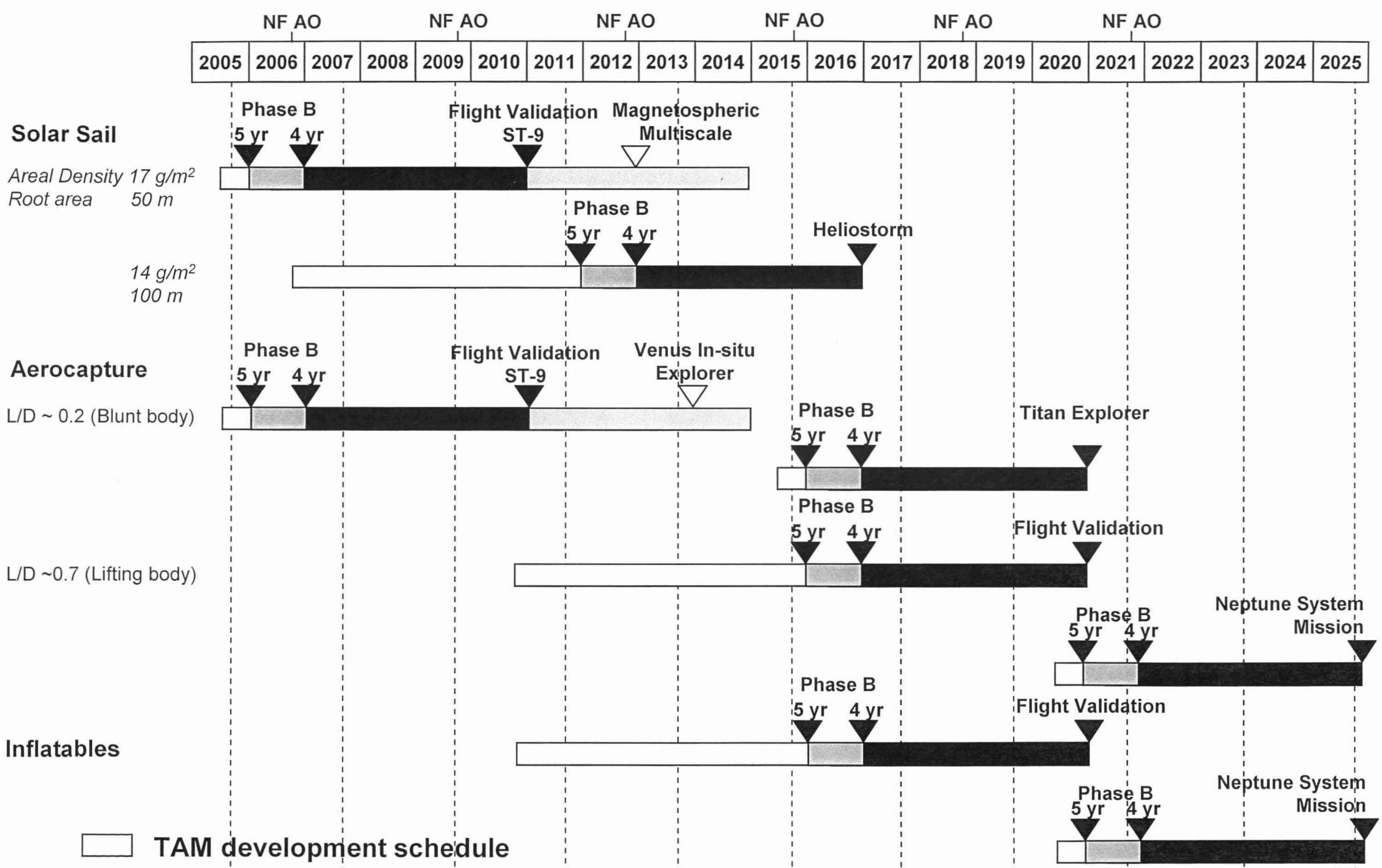
Solar Electric Propulsion

- 2007 Discovery AO for NSTAR with Near Earth Asteroid pacing mission
- 2007 Discovery AO for NEXT with CSSR pacing mission
- 2007 Discovery AO for Hall with Comet Rendezvous pacing mission

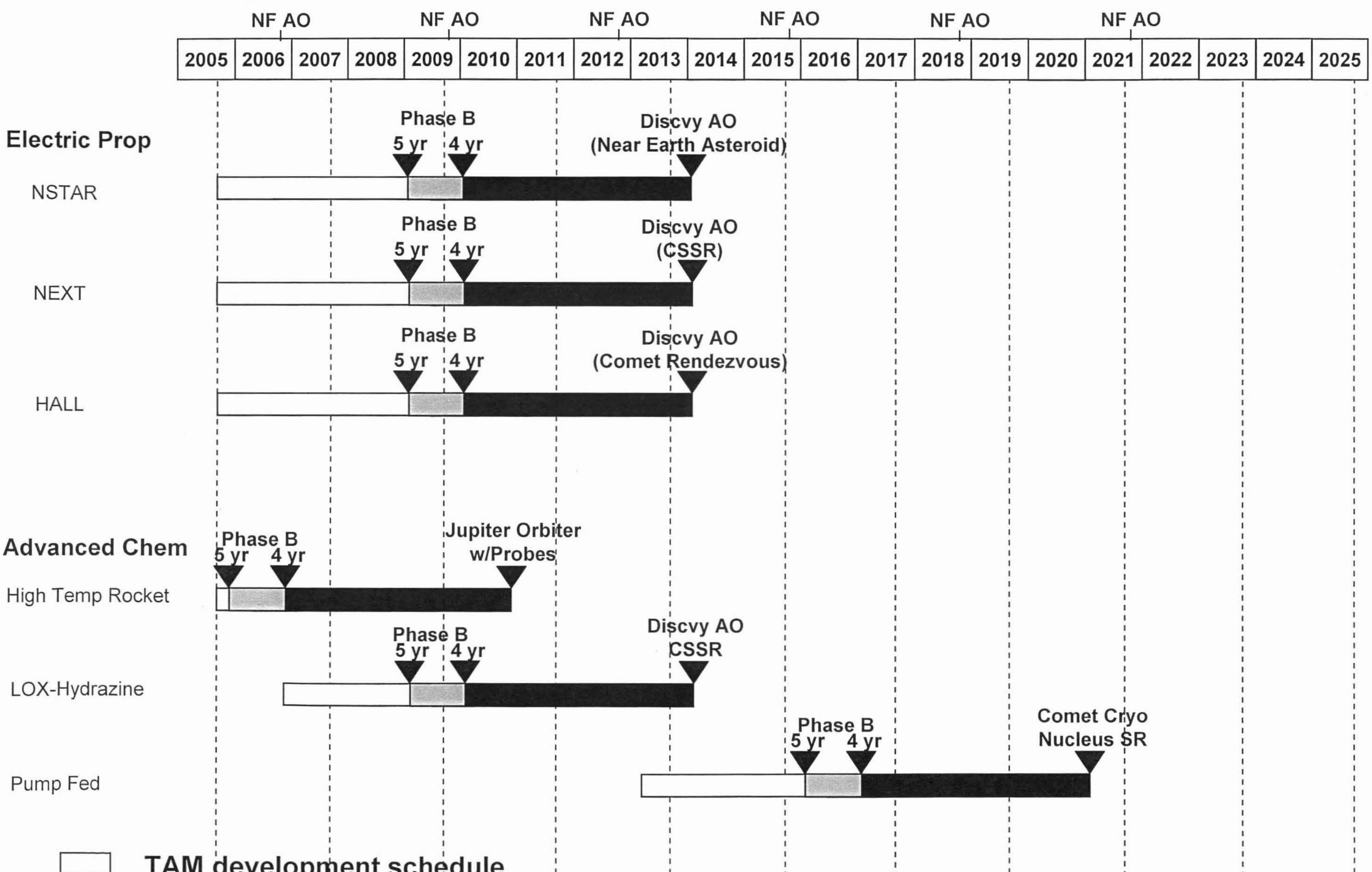
Advanced Chemical Propulsion

- 2007 Discovery AO, 2011 Jupiter Orbiter with Probes for High Temperature Rocket
- 2007 Discovery AO, 2013 CSSR for LOX-Hydrazine
- 2007 Discovery AO, 2020 Comet Cryo Nucleus SR for pump fed

Pacing Mission Technologies 1/2



Pacing Mission Technologies 2/2



Follow-on Activities

- Each Technology Area used the identified technology "need date" to back out a development schedule.
  - **In some cases, the need date was either not technically or programmatically possible. A later opportunity would become the pacing mission for technology development.**
- A pacing mission that was in the near future served to increase the priority for funding. A pacing mission that was much later decreased funding priority.
- After initial programmatic priorities and budgets were set, Technology Areas updated development flows and corresponding project schedules. The funding negotiation was an iterative process.
- The outcome was a much vetted and thoroughly scrubbed program spending plan that was presented to SMD Management as a technology development plan for FY06 and out years.
- FY06 Mid year (and beyond) budget reductions disallowed total implementation of the development plan produced.
  - **The process, resulting priorities and technology development plans allowed for timely restructuring of the budget/content for ISPT after the budget reductions**
  - **Program remains focused on high-priority product deliveries that will stay as aligned to customer priorities as possible**

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